Tech Fact Sheet

Savannah River National Laboratory ***South Carolina***

RadBall Technology
For Hot Cell Characterization

Challenge

Operations at various DOE sites have resulted in substantial radiological contamination of tools, equipment, and facilities. A critical step in planning and implementing Deactivation and Decommissioning (D&D) of contaminated facilities involves the development of an accurate assessment of the radiological, chemical, and structural conditions inside the facilities. The use of remote technologies to gather this information is imperative to keep worker exposures as-low-as reasonably achievable (ALARA) in these highly contaminated environments, which are usually associated with extremely high radiological dose rates. Quantitative characterization data obtained via remote technologies will allow more realistic selection of personal protective equipment (PPE) and increase operational efficiencies thereby reducing the associated cost.

Technical Solution

A new, non-electrical, remote radiation mapping device known as RadBall has been developed by the National Nuclear Laboratory (NNL) in the United Kingdom. The softball sized device offers a means to collect three-dimensional (3-D) information regarding the extent and distribution of gamma radiation in a given hot cell, glovebox or room. The constituent parts (Fig. 1) are an outer metallic collimation shell and an inner core. The inner core is made from a radiation sensitive polymer-based dosimetry material. As manufactured, the inner core is transparent; however, on exposure to radiation the material exhibits an increase in opacity. The outer collimation shell is cast from tungsten, and contains numerous individual collimation holes. Once the device is deployed in a radioactive area, the collimation shell partially attenuates or reduces the incident radiation while preferentially allowing radiation to pass through the collimation holes. This radiation then deposits opacity tracks within the inner core which can be analyzed to identify the location and quantity of the radiation sources. The orientation of the opacity track provides the positional information regarding the source (achieved by using a reverse ray tracing technique). The activity of the detected source is assessed by quantifying the magnitude of the opacity change (which follows a linear relationship with respect to absorbed dose). Radiation sources can be characterized by studying the depth of the opacity track (the measured opacity in the track over the depth of the track will follow a function that can be interpreted to estimate the characteristic energy or energies of the incident radiation source).

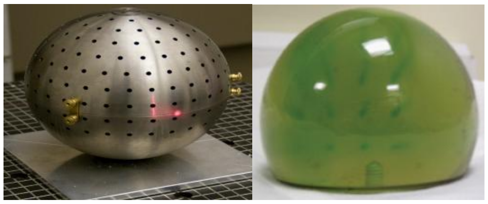

Figure 1: Two components of a RadBall device: the outer collimation shell and inner polymer core (Images: NNL).

Tech Accomplishments

Under an umbrella agreement between DOE EM and the UK Nuclear Decommissioning Authority and in close collaboration with the UK-NNL, RadBall technology was tested at Savannah River National Laboratory (SRNL) Calibration Facility in three phases to determine the optimal dose, collimator thickness and size of the holes. After irradiation, the RadBalls were sent to Duke University for optical scanning. Data from Duke University (Fig. 2) demonstrated that the technology responded well during these phases. The experiments highlighted that the optimal dose of absorbed radiation is around 3 gray(Gy) with a preferred collimator thickness between 5 and 10 mm and collimator hole sizes around 3 mm in diameter.

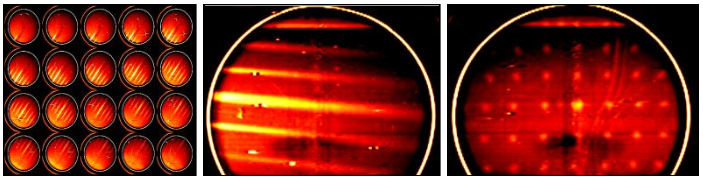

Figure 2: Optical scan images of RadBall irradiated with 5 Gy ^{137}Cs source (A: montage of vertical slices moving through RadBall top to bottom. B & C: side images) (Images: NNL).

Site Project & Identifier	Tech Stage: Demonstration
Hot Cell Characterization Project	Demonstrated in SRNL contaminated hot cell on September 1, 2009.

Field testing the RadBall technology was conducted in SRNL Hot Cell 9 in Building 773-A (Fig. 3). Since the RadBall was visible through shielded glass, orientation was maintained by visually taking measurements with a meter stick and manipulator arms. These tests have shown that the RadBall is effective in locating radiation doses from multiple angles and initial results indicate that from a distance of 1m, the technology is able to locate the radiation source within 1cm (a 1% accuracy error). The experiments have confirmed the linear response of the polymer opacity when exposed to increasing levels of radiation. Data analysis to confirm the ability of the RadBall technology to accurately characterize different radiation sources is ongoing along with development and building of the 3D visualization part of the technology to overlay RadBall data onto images of the radiation field environment. Future milestones involve the selection and utilization of a robot for remote RadBall deployment into highly contaminated facilities, portable optical scanner development, and RadBall deployment at another DOE facility using the robot and scanner to promptly obtain visualizations of the contaminated environment. Additionally, with the UK-NNL taking the lead, commercialization of the RadBall has been initiated.

A B

Figure 3: Hot Cell Demo Environment (A: Hot cells at SRNL. B: Hot Cell 9 used for demo) (Images: SRNL)

Impact

Application of this technology will allow characterization of highly contaminated areas and avoid the risk to personnel from hazardous levels of radiation. The small passive device does not require power and can be exposed in small confined rooms (3 m x 3 m). Multiple RadBalls can be used for larger areas.

Lessons Learned

Minor RadBall design modifications should be made to improve the polymer alignment with the collimator (facilitate the centering of the polymer within the collimator), increase the number of collimator holes (in lower RadBall section), change the square shape of the support base to a circular shape to avoid sharp edges, reduce polymer defects, standardize the polymer size and shape, and include a hook on top of the collimator for better handling. These suggested modifications have been communicated to the UK-NNL for consideration.

Impact and Features

- No power requirement
- Small size allows for utilization in small confined areas
- Simple technology and inexpensive compared to alternative radiation detection devices deployed in these environments
- Ability to locate and quantify radiation sources over a wide dose range
- Offers potential to characterize different radiation sources
- Linked with computer technology, the RadBall data can be overlaid onto a 3D visualization of the radiation field environment

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Technology Name	RadBall
Federal End User Information	TBD
Tech User Information	TBD
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Challenge Category	Tech Solution Category
• Characterization	• Characterization
• Dismantlement	• Waste Handling & Packaging
• Deactivation	• Robotic & Remote Systems
• Remote Access	• Worker Safety